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Abstract. One of the features of the wheat market in the eighteenth and nineteenth centuries was the existence of marked regional differences: wheat prices in coastal Spain were higher and less volatile than those of inland regions. The aim of this paper is to explain these differences. The analysis is based on the so-called homogeneity condition and Fogel's method for calculating the slope of the demand curve. According to the former, the sum of price elasticities, income and substitute goods must be equal to zero. Fogel's method makes it possible to estimate the elasticities of demand without contemporary data on prices and consumption. This study draws two main conclusions. First, wheat price elasticities in Spain are not markedly different from those across the rest of Europe. Nevertheless, the demand curve in inland regions is slightly more rigid than that of the rest of the country. Second, income elasticities grew slightly during the eighteenth and nineteenth centuries. This preference for wheat reveals an improvement in market conditions and the standard of living.

Résumé. Une analyse du prix du blé en Espagne (1765-1855). Le marché du blé aux XVIII[e] et XIX[e] siècles se caractérisait par l'existence de différences régionales marquées. La principale différence était que le cours du blé sur la côte espagnole était plus élevé et plus stable qu'à l'intérieur du pays. L'objectif de cet article est d'expliquer ces différences régionales. Il s'appuie sur la condition d'homogénéité et la méthode de Fogel pour calculer la pente de la courbe de la demande. En vertu de la première, la somme des élasticités prix, revenus et biens de substitution est égale à zéro. Cette méthode permet d'estimer les élasticités de la demande en l'absence de données contemporaines des prix et de la consommation. Cet article retient deux conclusions principales. Premièrement, les élasticités de la demande de blé en Espagne n'étaient pas si différentes de celles constatées dans le reste de l'Europe. Il convient néanmoins de souligner que la courbe de la demande intérieure était un peu plus rigide que dans le reste du pays. Deuxièmement, les élasticités des revenus ont légèrement augmenté au cours des XVIII[e] et XIX[e] siècles. Cette préférence pour le blé témoigne d'une amélioration des conditions de marché et des niveaux de vie.

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The aim of this study is to identify the reasons for regional differences in the variability of Spanish wheat prices. This problem is part of a larger one: determining the regional differences in price according to means, cycles, seasonality and variability. This topic has generated long debates between Spanish economic historians. For example, price differences between regions have often been explained as a consequence of the high costs of transport. This explanation could be applied to the seventeenth or eighteenth centuries but not to the nineteenth century[1].

There must be other relevant variables that explain the features of the series of prices. Generally speaking, coastal wheat prices were high and steady, whereas inland prices were low and unsteady. This situation is reminiscent of the wheat market in Europe in the nineteenth century regarding English and Prussian prices. However, Spain is not a continent, but a mountainous, medium-sized country with a rich variety of climates.

There are two hypothetical explanations for the price differences. On the one hand, the variability of prices in Spain may have been due to the existence of regional differences in production and consumption. Thus, the single-crop farming of wheat in Inland Spain would explain the low price of wheat in this region; however, the failure of harvests would have also raised the price during the crises of subsistence. On the other hand, price variability may have depended on differences in personal incomes. The purchase of wheat by comparatively richer inhabitants of Coastal Spain would have reduced the consumption in Inland Spain.

1. Agricultural productions in Spain

From the point of view of agrarian goods consumption, it would be possible to distinguish three large Spanish regions[2]. The first one is Inland Spain: the « two » Castiles, Madrid, Extremadura, La Rioja, Aragón and the north of Andalusia. Paths leading to the coast were difficult to cross due to the existence of parallel ranges of mountains to the sea, the lack of navigable rivers and the political division of the peninsula. In this part of the country, there existed sheep livestock; but cattle were only important

1. Ringrose, D. S., 1972; Madrazo, S., 1984.

2. Connard, P. & Lovett, A., 1969, p. 412, made a similar distinction. The main difference is that the Mediterranean region spans « from Llobregat to Segura »; instead, they excluded Andalusia.

in the regions nearest to the Cantabrian Mountains and the north of the Portuguese frontier.

Agricultural production in this wide region was based on the Mediterranean « triad »: vineyard, olives and wheat. Climate and soil conditions in Inland Spain did not permit the cultivation of other crops, such as corn. The cultivation of potato was possible, but it did not begin until the end of the eighteenth century for several reasons. Even halfway into the century, there was no evidence of its large-scale consumption by the popular classes. Data from the first agricultural inventories – *Junta Central de Agricultura*, 1857 – do not suggest that potatoes were consumed in significant amounts. This hypothesis is corroborated by fiscal evidence, such as the *impuesto de puertas* – municipal tax – of several cities. Indeed, its consumption seems to have been higher in some parts of the Duero Basin than in other inner regions.

Figure 1. *Spanish Consumption regions*

Source. The author; from *el Censo de Manufacturas*.

In sharp contrast to Western European countries, only one species of cereal, wheat, provided most of the nutrients. Table 1 shows the share of main cereal productions in the three large Spanish regions according to the *Censo de frutos y manufacturas* (1799), an official registry. In Inland Spain, only wheat represented more than half of all cultivated cereals. Rye constituted one-fifth of all cereal production; it was farmed in the cold regions and highlands, such as the provinces of León and Soria. Corn, *escanda* (an inferior race of wheat) and millet were unknown. A little more than one-quarter of production was composed of cereals devoted to animal feed: oats and barley. The quota of the first was less than 4.0 per cent[3].

Table 1. *Share of each cereal in Spanish production (weight*) in 1800*

	wheat	*rye*	*escanda*	*barley*	*oats*	*corn*	*millet*
North**	18,6	28,5	3,0	2,6	1,8	44,7	0,7
Inland	55,4	17,9	0,9	21,0	3,9	0,9	0,1
Mediterranean	52,5	12,6	0,7	18,4	2,0	13,8	0,1
Spain	51,9	18,0	1,0	19,1	3,5	6,3	0,1

Source. *Censo de Frutos y manufacturas*.

* Weight conversion rates are 780 g/l for wheat, rye and *escanda*; 750 g/l for corn and millet; 600 g/l for barley; and 550 g/l for oats.

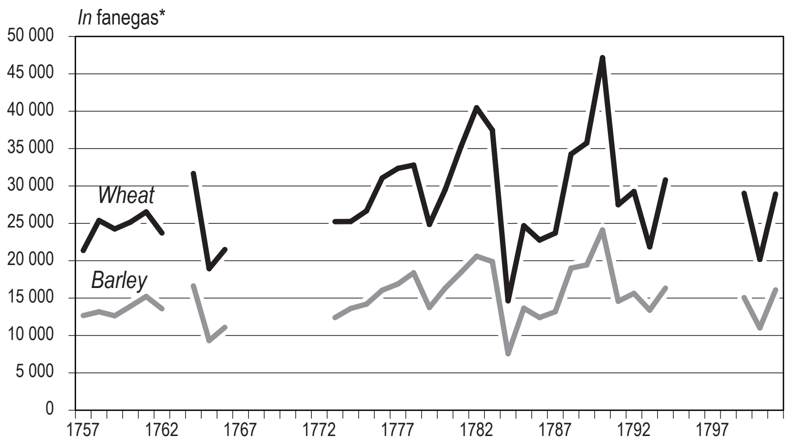
** North region includes Galicia, Asturias, Biscay and Guipúzcoa. Mediterranean region includes Catalonia, Valencia, Murcia, Granada and the Balearic Islands. The rest of the country is « Inland ». The Canary Islands are not included.

In Spain, the correlations between series of wheat, rye and barley productions were higher. Figure 2 shows the tithes collected by the Archbishopric of Seville in the second half of the eighteenth century. The wheat and barley series are extremely similar. With an almost imperceptible trend, the coefficient of determination is 0.96. This strong relation is a consequence of the special climatic conditions of Western Andalusia. In this region, the main reasons why a harvest could fail were the lack of spring rains and the high temperatures in May-June. These problems were common to all cere-

3. As a source for the study of agricultural production, the *Censo de Frutas y Manufacturas* presents several problems. First, it is based on the ancient provincial division of Spain, which is different from the situation today. Moreover, some provinces such as Navarre and Catalonia were not uniform in their consumption patterns. Finally, there is some uncertainty in the data. For instance, agricultural production in Soria is clearly overestimated. The correction of these problems would strengthen the importance of wheat in Inland Spain and would reduce the importance of corn, *escanda* and millet to zero. The opposite would hold for the North.

als. In Castile, where the influence of other factors such as the spring frost or the lack of autumn rains weighed more heavily, this correlation was less intense. However, as we will discuss later, the strong similarity in the evolution of prices of different cereals in Rioseco is related to the fact that their production in Castile was highly correlated.

Figure 2. *Tithes in the Archbishopric of Sevilla (1757-1801)*



Source. Martín, M., 1970, p. 168-169.
* 1 *fanega* (Spanish traditional unit) = 55,5 litres.

The agricultural region of the north includes the provinces flanked by the Bay of Biscay, from Galicia to the Basque Country, the Pyrenees and other very humid regions. The distinguishing characteristic of these territories was the mixed farming. Generally, the main crop was corn (see Table 1). Its cultivation probably began at the end of the sixteenth century. According to the *Catastro de Ensenada*, 1749-1756 – a national fiscal inventory –, in the middle of the eighteenth century, all of the villages of Galicia and Asturias farmed corn. In some villages, corn was the only cereal harvested. Usually, however, wheat, rye and millet were also cultivated. In the eastern provinces of Bay of Biscay, Cantabria and Vasque Country, millet was unusual. Instead, wheat was more common, even exceeding the popularity of corn. Rye was likely more typical than corn or wheat in the highlands of this region.

Moreover, there were other nutritional alternatives. Starting in the eighteenth century, potatoes were cultivated in some places in the north.

Chestnuts had long been a common food in Asturias. There were more cattle in the Cantabrian regions than in the rest of the nation. Consequently, inhabitants had a regular supply of meat and milk products. Fish, especially cod, was eaten by people living along the coast, and of course, access to the sea allowed a regular supply of wheat from overseas.

The third region was the Mediterranean coast. West Andalusia – the provinces of Seville, Cadiz and Huelva – could be assimilated to this region. However, some of the features of consumption in this region are more similar to those of Inland Spain. In the Mediterranean region, the products of the « triad » were dominant, though the production of wheat was lower than that in Castile, with high oil and vine productions. Indeed, these goods were exchanged for wheat and flour from Castile and Aragon.

On the other hand, there were other crops to substitute wheat: rice and corn. The former was cultivated in two small regions, Ebro Delta and, mainly, *La Albufera* in Valencia. Corn was farmed in several humid regions in the province of Cádiz and, with irrigation, in Valencia. This method of cultivation was the basis of mixed farming in the Southeast of Spain, where frequently dry-farming grains was not possible or profitable. In the Mediterranean region, vineyard harvests alternated with several commercial products, though subsistence products – *batatas* or *higos chumbos* – were cultivated as well. Fishing activity was less popular than in the northern coast, but it had some importance. Of course, coastline cities could obtain wheat from overseas. In general, food variety was poorer than in the North, but better than in Inland Spain. Perhaps the most remarkable feature of food consumption in the Mediterranean coast was the dependence on Castilian and foreign wheat.

2. Agricultural prices

Quantitative information about agricultural production prior to the end of the nineteenth century is scarce and fragmentary. We can recognise great cycles: growth in the sixteenth century, recession at the end of that century and in the first half of the seventeenth, new expansion in the second half of the seventeenth century and the eighteenth century, crisis between centuries, and new and strong growth in the nineteenth century. These cycles basically reflected the fluctuations in the wheat market. They were not regular or precise.

However, there is a great deal of data regarding agricultural prices, especially the price of wheat. There are some monthly series of prices of wheat and other goods that cover two or three centuries. In Spain, as in the rest of Europe, there is an extensive literature concerning prices[4]. Today, all of the relevant information from *mercuriales* – municipality records of subsistence prices – has probably been extracted, although it would be possible to obtain new data from other sources (for example, periodical papers).

Table 2. *Volatility of wheat prices (coefficients of variation)*

Region	*City*	*Average*	*Coef var*
North	Tolosa	24,45	27,85
	Gerona	27,31	31,17
Mediterranean	Barcelona	25,20	28,29
	Valencia	21,20	32,56
Inland	Rioseco	16,07	59,37
	Pamplona	17,11	40,75

Source. *Mercuriales* from cities.

One of the most remarkable features of Spanish wheat prices is the presence of large regional differences. Table 2 shows the average and coefficients of variation (standard deviation divided to the mean) for six series of prices during the period 1766-1865[5]. Inland cities – Medina de Rioseco and Pamplona – have lower averages and higher coefficients of variation than coastal cities. The most expensive wheat was sold in Gerona, a northern Mediterranean city. Cheaper wheat was sold in Rioseco, at the centre of the Basin of Duero. Perhaps the less coherent result comes from Valencia, where wheat production was higher than in Inland cities but cheaper com-

4. For the eighteenth century or prior, there are studies about prices for Madrid (Reher & Ballesteros, 1993(), Medina de Rioseco (Yun, B., 1991), Segovia (Anes, G. & Le Flem, J., 1965), Tolosa (Fernández, P., 1977), Pamplona (Arizcum, A., 1989), Lleida (Vicedo, E., 1983), Valencia (Palop, J. M., 1977), Barcelona (Vilar, P., 1987), Tàrrega (Garrabou, R., 1970) and all Catalonia (Feliu, G., 1991). For the nineteenth century, and moreover the works of Reher and Ballesteros, Yun, Arizcum and Vicedo, there are studies for Santander (Martínez, T., 1999), Gerona (Portella, J. & Alberch, R., 1978), Oviedo (Zapico, J. L., 1973), Morón de la Frontera (Bernal, A.-M., 1979). I have collected all of the series of nineteenth-century prices from the original sources. They can be found in www.iisg.nl/hpw/data.php#spain. Likewise, I have collected the series of eighteenth century prices for Tolosa, Gerona, Barcelona and Medina de Rioseco. Bartolomé Yun kindly gave me a copy of the last mercurial.

5. Traditionally, Spanish local authorities could regulate wheat prices through the *tasa*, an upper-limit price imposed during crises of subsistence. However, in 1765, it was suppressed. That is one of the reasons why the scope of this paper begins in that year.

pared to that in Barcelona. In any case, proximity to the sea seems to be a strong determining factor of price conditions.

3. Theoretical framework

Homogeneity condition

Conventionally, the consumption of a good *C* is determined by its own price *p*, the price of substitute goods *pS*, the income of consumer *Y* and consumer preferences and tastes *T*. Usually, the last variable is ignored.

$$C = f(p, pS, Y, T) \qquad [1]$$

According to Euler's theorem, if [1] is a homogeneous function of degree 0 (that is to say, if we multiply all of the independent variables by the same amount, the result does not change), then:

$$C = C_0 \cdot p^{b1} \cdot pS^{b2} \cdot Y^{b3} \qquad [2]$$

where b_1, b_2 and b_3 are the price elasticity of demand, the cross-price elasticity and the income elasticity, respectively. If we take the logarithm, then:

$$\log C = b_1 \cdot \log p + b_2 \cdot \log pS + b_3 \cdot \log Y \qquad [3]$$

From this equation, we can obtain the elasticities. For example, the price elasticity of demand would be:

$$b_1 = \frac{\log C - b_2 \log pS - b_3 \log Y}{\log p} \qquad [3a]$$

$$b_1 = \frac{\delta \log C}{\delta \log p} = \frac{\delta C / \delta p}{C / p} \qquad [3b]$$

There is an interesting implication called the « homogeneity condition » that states that for any good, the sum of its price elasticity of demand, the cross-price elasticities of its substitutes, and the income elasticity of consumers is equal to zero. This is not a probabilistic result or a derivation of the Consumer Theory, which depends on a large number of *ceteris paribus* conditions. It is simply an inevitable conclusion of the same assumption of that theory[6]. A full study of the elasticities of any good always offers such

6. See L. Philips, 1974, p. 34-38 and W. G. Tomek & K. L. Robinson, 1990, p. 36-38. The proof is simple. According to Euler's theorem, a function $z = f(x,y)$ homogeneous in degree r is satisfied such that:

a result[7]. Therefore, if we could estimate some of those elasticities, it would be possible to estimate others. However, we need a starting point.

Fogel's method for the estimate of price elasticities of demand

In 1991, Robert Fogel published a paper about famine and food before the Industrial Revolution[8]. Fogel reported a method to estimate wheat price elasticity with price and output data from different places and periods. This is an important matter because there are often no peer data for those variables. In fact, Fogel was not the first to use this procedure. Before him, Robert Lehfeldt used the same scheme to estimate a *global* wheat price elasticity[9]. Moreover, three decades later, Giuseppe Parenti, who did not know of Lehfeldt's work, used the same method to estimate wheat price elasticity in Siena during the Premodern Age[10]. It seems that Fogel did not know of Lehfeldt's or Parenti's work either.

The supporting idea is simple: a low elasticity of demand implies large fluctuations in prices with respect to consumption. Therefore, if we have two representative samples of prices and quantities for the same geographical area, even if they have been obtained from different times, we

$$x\frac{\delta z}{\delta x}+y\frac{\delta z}{\delta y}=rz$$

Consequently, if r = 0,

$$pT_i\frac{\delta CT_i}{\delta pT_i}+pS_i\frac{\delta CT_i}{\delta pS_i}+Y_i\frac{\delta CT_i}{\delta Y_i}=0$$

Dividing all terms in the equation by CT_i produces

b1 + b2 + b3 = 0.

7. For example, the elasticities of the consumption of beef in the United States between 1953 and 1983 were K. S. Huang, 1985, p. 46:

Price elasticity of demand	– 0.62
Cross-elasticity (pork)	0.11
Cross-elasticity (lamb)	0.01
Cross-elasticity (chicken)	0.06
All others cross-elasticities	– 0.01
Income elasticity	0.45
Sum	0.00

8. Fogel, R., 1992, p. 184-255.

9. Lehfeldt, R., 1914, p. 212-217.

10. Parenti, G., 1942, p. 176-216.

could estimate the elasticity of demand through the comparison of their oscillations. Thus, Fogel used the following relationship:

$$\varepsilon = \frac{\delta_C}{\delta_p} r_{Cp}$$

where δ_C is the standard deviation of the quantities of wheat consumed, δ_p is the standard deviation of wheat prices, and r_{Cp} is the correlation coefficient of both. The series of prices and quantities need not be contemporary; they must only be representative of the same region during the same period. Obviously, they could show different trends. For this reason, Fogel and others estimated the elasticity of demand through the relationship between standard deviations of de-trended series of quantities and prices.

Of course, the crucial issue is the agreement between series of wheat production and prices. There are three factors that could break such agreement: first, the trade between regions with surplus and excess wheat; second, long-term wheat storage or « carry over »; third, the « seed factor » or the use of a fixed part of the harvest as seed. In each case, the effects on the estimation are different. Trade and storage would smooth the volatility of consumption in relation to production. Therefore, they would reduce the elasticity of demand. The seed factor would have the opposite effect.

The incidence of trade, carry over and seed factor prevent an accurate estimate of elasticity. The importance of the biases depends on historical circumstances. An integrated market could balance regional deficit and surplus through trade. In this way, the main effect of the integration would be to obtain a wider market size. For this reason, a « selfish » granary or rather a granary that does not exchange grain out of its area of influence could experience a worse crisis of subsistence. In any case, it is clear that a crucial issue to resolve in the econometric problem estimating the elasticities is determining the frontiers of the market

Europe between the sixteenth and eighteenth centuries is a suitable field of study because road transport and storage effects were not large, and seed factors were well known and few. Unfortunately, there are not many studies in this regard. For Sweden and Europe as a whole, Persson and Barquín, respectively, obtained almost the same result: a price elasticity of demand of –0.65[11]. The elasticity estimated by Fogel for Great Britain in the Premodern Age was higher, though it featured a numerical error. Once

11. Persson, K. G. P., 1999, p. 52-54; Barquín, R., 2005.

it is amended, the result is –0.37[12]. However, the elasticities calculated by Parenti in Sienna for the sixteenth and the seventeenth centuries ranged from –0.7 to –1.0. In short, –0.65 seems a reasonable estimate for Premodern Europe.

4. Spanish wheat elasticities

Some necessary assumptions

According to the homogeneity condition and the regional division of Spain,

$$0 = b_{1n} + b_{2n} + b_{3n} = b_{1m} + b_{2m} + b_{3m} = b_{1i} + b_{2i} + b_{3i} \qquad [4]$$

where b_1, b_2 and b_3 are the elasticity of demand, the cross-price elasticity, and the income elasticity. The suffixes 'i', 'n' and 'm' refer to Inland, North and Mediterranean Spain. With signs, the function is written as follows:

$$0 = -b_{1n} + b_{2n} + b_{3n} = -b_{1m} + b_{2m} + b_{3m} = -b_{1i} + b_{2i} + b_{3i} \qquad [5]$$

Obviously, the implicit system cannot be solved. It is necessary to introduce some assumptions. First, the Inland cross-elasticity b_{2i} should be considered equal to zero. There are three reasons to do so. First, as shown above, in this region, wheat played a dominant role in consumption. Corn, *escanda* and oat productions were negligible. Normally, rye, the closest cereal to wheat, was used to make several kinds of brown bread, with more or less amounts of wheat. Therefore, only barley could play a role in the stabilisation of consumption. Although a part of the production was eaten as soup or porridge, another part could shift from being used in brewing and fodder to being used as human food[13]. However, in many cases, this was not possible. It should be noted that some of the main consumers of barley were high nobility or the horses of the army[14]. As shown in Table 1, in Castile (and Spain) barley occupies only a fifth of total cereal production. In short,

12. Barquín, R., 2005, p. 251.

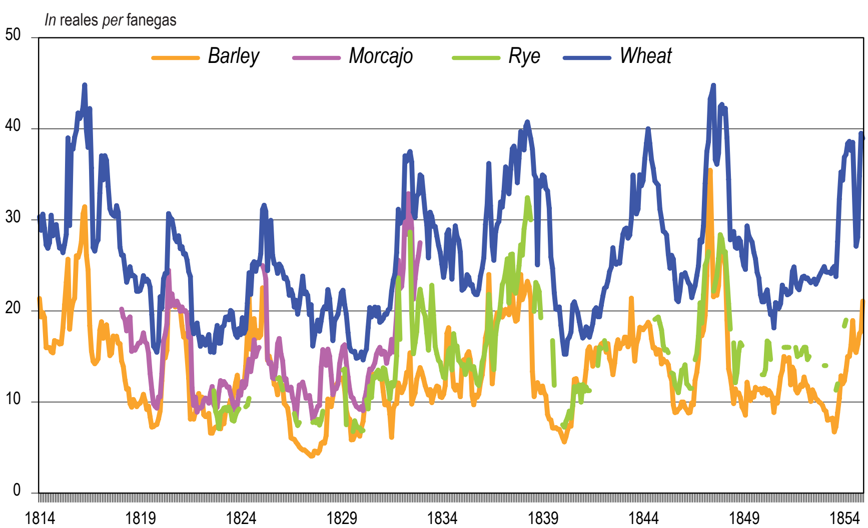
13. For example, C. Boutelou, 1818, p. 91, wrote: « The grain of bare barley is similar to wheat, and it can be used for making bread, although its more common use is to eat into soup and others ways like the rice ». A. Oliván, 1857, p. 81, said: « The grain of barley is used as fodder, sometimes its flour is mixed with wheat or rye ones, and mainly in the brewing ». A century later, J. Farrás, 1956, 159 said: « The barley is difficult to convert into bread, and for this reason it is not used for human feeding. However it is an excellent fodder for the cattle, and the basis to the brewing ».

14. One of the reasons of the success of mules in the nineteenth century Spain was that, unlike horses, mules could eat all kinds of fodder and pasture.

barley production was relatively small; part of this production was usually eaten, and only part of the barley « not used in the human feeding » could be used in this way.

The second reason is that the prices of rye and barley followed the trend of wheat. Figure 2 shows the prices of cereals in Medina de Rioseco between 1814 and 1854. Table 3 shows their coefficients of determination. The correlation between wheat and rye and that between wheat and *morcajo* (as French *meteil*, a mix of rye and wheat) is higher, 0.83. The correlation between wheat and barley is good, 0.54. In all of the cases, the trends are null and the movements of prices are similar. We have seen before that the main cause of these movements is the common fluctuation in production. Now we can understand the meaning of this synchrony. During a bad harvest or crisis of subsistence, rye (or even barley) could only be a partial alternative to wheat. Bakers had to pay a high price for the cereals that they mixed with wheat because their harvests were also small. Obviously, the influence of this mix on the final price was reduced. It was probably for this reason that a more typical answer was to reduce the weight of every piece of bread.

Figure 3. *Price of cereals in Rioseco (1814-1854)*



Source. *Mercuriale* of Medina de Rioseco.

Table 3. *Coefficients of determination between prices of several cereals, 1814-1854*

	Wheat	*Barley*	*Rye*	*Morcajo*
Wheat	1,00			
Barley	0,54	1,00		
Rye	0,83	0,62	1,00	
Morcajo	0,83	0,34	0,88	1,00

Source. *Mercuriale* of Medina de Rioseco.

The third reason is the density. A litre of rye or wheat is heavier than a litre of barley. It is difficult to know exactly how much because the strains have changed. For example, the main Spanish strain of wheat in the nineteenth century, *candeal-chamorro*, is currently unknown to farmers. If it were assumed that nineteenth-century barley « commonly » weighed 600 g/l (today, it ranges from 500 to 600 g/l), the difference in weight between it and the *candeal-chamorro* (780 g/l) would be 23.1 per cent. Thus, the price of barley in terms of weight would be similar to that of rye. For example, in Medina de Rioseco between 1829 and 1833, the prices of barley and rye were 58.8 per cent and 59.5 per cent those of wheat, respectively.

In short, there were few alternatives to wheat. The most obvious, rye, was also the least interesting because the movements of its production were similar to those of wheat. Barley, a cereal devoted to animal feeding, would be a secondary or extreme option. In both cases, the similarities in the movements of prices reduced their roles as wheat substitutes.

A second assumption is that cross-elasticities in the northern region were higher than those of the Mediterranean ($b_{2n} > b_{2m}$). Above, we have discussed this issue. The basic argument is based on the different regional food alternatives.

A third assumption is that income elasticities in the Mediterranean and Inland regions were similar and lower than those in the North region. For the first decades of the nineteenth century, it is possible to perceive some of the social and economic features of the twentieth century, such as the unequal regional distribution of income. Generally speaking, coastal regions were richer than inland ones due to the development of their industry and the existence of a market-oriented agriculture. However, there are several reasons to assume that these differences were not significant.

First, we can find exceptions to the relationship between the coastal location and income. In relation to others, coastal regions such as Catalonia and Andalusia were rich. However, others such as the Southeast, Balearic Islands and Galicia, were not. Inland Spain, Castile and Extremadura were also poor regions; however, Madrid and the Valley of Ebro seem to have been rich regions. Indeed, regional inequality was smaller, in accordance with the larger rural population. Moreover, before 1850, more than 70 per cent or 80 per cent of Spanish people were peasants who lived in villages. The trade of agrarian products was very deficient due to the lack of means of transport or surpluses in agricultural production. A great majority of peasants worked in traditional farming. The only active exchange was the sale of a small part of their harvest in the nearby cities. Under these circumstances, there were probably no large differences in the standard of living among peasants between regions.

For these reasons, the main factor that can explain the regional differences in the income elasticities is the consumption basket. According to economic theory, it is normally assumed that bread is a good with a low, even negative, income elasticity. However, in Premodern economies, this value was positive. Only in this way is it possible to explain how wheat consumption per capita in Europe grew during the first decades of the twentieth century. This behaviour was due to the different preferences of consumers for each type of bread. Unlike wheat, corn, rye and other cereals had lower, likely negative, income elasticities. During the nineteenth century, many Europeans were replacing the consumption of these cereals with that of bread. The process was similar in Spain, with one important difference: the lack of better alternatives made Spain a « pioneer » in Europe. At the end of the eighteenth century, most of the cereal grown in Central and South Spain was wheat. The replacement of corn consumption with that of wheat was limited to the North, and only after 1850.

At this point, the behaviour of the market beyond the frontier may be relevant. North and Central Portugal (where most of the Portuguese people lived) had an agrarian structure similar to the northwest of Spain. Corn was the main crop, but other cereals were also cultivated. According to Lains, Portugal's income elasticity in 1850 was 1.40[15]. It is reasonable to suppose that this value could be a good estimate of the income elasticity in this part of Spain. In fact, the construction of the railway in this region (dated from 1860 in Basque country/Cantabria to 1880 in Galicia) led to the replacement of corn consumption by wheat consumption, especially in

15. Lains, P., 1995, p. 172-174 and 195.

rural areas. These changes did not occur in the rest of Spain because these regions did not experience the relevant consumption of other cereals. The income elasticity in North Spain was necessarily higher than that of Central or South Spain.

In short, [4] can be reduced to

$$0 = -b_{1n} + b_{2n} + b_{3n} = -b_{1m} + b_{2m} + b_{3mi} \quad -b_{1i} + b_{3mi} \quad [6]$$

where the suffix mi includes Mediterranean and Inland regions. Moreover, it is important to note that:

$$b_{3n} > b_{3mi} \quad [7]$$

A direct estimate of the elasticity of demand

To solve [6], the first step is to estimate the elasticities of demand. A first approximation could be obtained by data from Medina de Rioseco in the period 1765-1801. The series of yields could be compared with contemporary price series. If we assume that a production series is a good proxy for consumption series, we could estimate the elasticity of demand through the following regression:

$$\mathrm{Ln}\, C = a + b \cdot \mathrm{Ln}\, p + c \cdot \mathrm{Ln}\, Y$$

where C is the consumption – production –, p is the price, Y is the income per capita and b and c are the elasticities for price and income, respectively. In fact,

$$e = \frac{\delta C / C}{\delta C / p} = \frac{b / C ? p}{p ? C} = b$$

and the same reasoning is valid for c. We do not have an actual income per capita series, but we can use a proxy, the series of nominal salaries from Palencia, a small city near Medina de Rioseco[16]. The terms of the regression are:

$$\mathrm{Ln\ C} = -2.11 - 0.56 \cdot \mathrm{Ln\ p} + 1.04 \cdot \mathrm{Ln\ Y}$$

$$(-0.90)\ (-3.31) \qquad (1.95)$$

$$R^2 = 0.27 \qquad n = 36$$

16. Moreno, J., 2001, p. 33-34.

A price elasticity of –0.56 is a plausible result. However, an income elasticity close to unity implies a normal preference for wheat. This seems strange, though possible. In any case, the coefficient of determination is too low to allow for strong confidence in this regression. On the other hand, through this method, we can only estimate the value of the price elasticity of one city. Certainly, Medina de Rioseco is one of the most interesting markets in Spain due to its location in the centre of the main cereal region[17]. However, it is only one market.

Indirect estimates of the elasticity of demand

It would be useful to search for estimates in other cities through the Fogel method. For the period 1765-1850, we have several series of wheat prices from *mercuriales*. Additionally, since 1890, the Public Administration recorded agricultural production data for all of the Spanish provinces[18]. Thus, we can compare the volatility in different samples of production and prices to estimate the price elasticities. This requires taking two assumptions into consideration. First, the variability in cereal production at the end of the nineteenth century was similar to that of the eighteenth century. Second, the oscillations in consumption were similar to those in production.

Trends in the volatility production

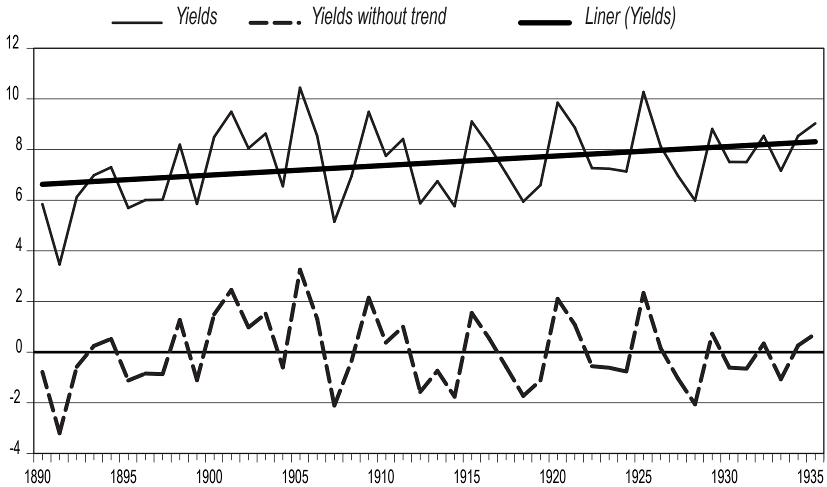
With respect to the first assumption, Fogel provides some evidence that in a dry-farming system modernisation involves an increase in production but not in volatility[19]. Spanish data suggest something similar. Figure 4 shows two series of yields and detrended yields (percent data) in the province of Valladolid from 1890 to 1935. The starting point coincides with the approval of protectionist Tariff Cánovas, which caused a strong increase in the internal prices in Spain and the modernisation of Spanish agriculture. For this reason, the original series show a gradual trend. During those decades, every harvest changed 19 per cent (up or down) with respect to a normal year. Nevertheless, there is nothing that involved changes in the variance (in econometric terms, heteroscedasticity). The volatility in the first years is similar to that of the last ones. In short, there is no evidence that modernisation increased the variance.

17. Escrivá, J. L. & Llopis, E., 1987, p. 126, define as « surprising » the intensity of « leadership » in the Castile markets.

18. This information has been collected by Gehr, 1991.

19. Fogel, R., 1992, p. 252.

Figure 4. *Yields in the province of Valladolid (1890-1935)*



Source. GEHR, 1991.

In Table 4, there appears another piece of evidence. The table shows some statistical descriptors of three series of yields or tithes in the second half of the eighteenth century compared with others calculated with provincial data between 1890 and 1914. CV is the Coefficient of Variation of the original series. The other two columns show the standard deviation of detrended series through two methods: Ordinary Least Squares (OLS) and Mobile Average (MA). Note that any standard deviations in a village must be higher than those in a province because the territory is smaller. In fact, the volatility in the series of Rioseco and Aranjuez (MA) in the eighteenth century is higher than that of their provinces in 1890-1914. However, the volatility in Seville and Aranjuez (OLS) is smaller.

It is possible that in Central and Southern Spain, the use of fertilisers strongly increased cereal production during the good (and wet) years. However, this did not occur during years of drought. In any case, there are no reasons to believe that volatility in the eighteenth century harvests was greater, or smaller, than in the beginning of the twentieth century. Agricultural modernisation did not cause a reduction in the production volatility.

Table 4. *Production volatility in three cities*

City/Province	*Data*	*CV*	*OLS*	*MA*
Aranjuez/Madrid	1765-1808 Local	28,4	0,31	0,26
	1890-1913 Provincial	40,2	0,33	0,16
Rioseco/Valladolid	1765-1808 Local	34,2	0,38	0,30
	1890-1913 Provincial	22,7	0,26	0,17
Seville/Seville	1765-1808 Local	25,0	0,31	0,20
	1890-1913 Provincial	52,0	0,71	0,50

Source. Yun, B. 1987, Anes, G., 1970, Martín, M., 1990, and GEHR, 1991.

Seed, storage and trade

The second assumption is that the oscillations in consumption were similar to those in production. This is because the biases from long-term storage, trade and seed factor did not affect the result because they were low or they eliminated one another.

The seed factor had a small and well-known effect. A part of the harvest was dedicated to seeds; therefore, the volatility of the consumption – rather, the farm production devoted to people and animals – was higher than that of production. Only at the end of the nineteenth century was this factor clearly reduced. Consequently, we can assume that the estimate of the elasticity of demand hides a small bias.

However, this bias may likely be compensated by the effect of the *pósitos* network and the carry-over storage. In the eighteenth century, Spain built the largest long-term wheat storage system in Europe, the system of *Reales pósitos*, which reached its peak during the last years of the century[20]. According to official data (which did not include *municipal pósitos*) in 1800, 5,151 silos were associated with the network and stored more than five million hectolitres of cereal, mostly wheat. This would have been a quarter of the national harvest in a normal year. It is interesting to note that the Spanish *pósitos* web was an anachronism in eighteenth century Europe[21]. Almost every country had abandoned these storage systems because their maintenance costs were high and did not avoid the large oscillations in prices. Only some small conservative (and theocratic) states, such as the Vatican and Geneva, supported them[22].

20. Anes, G., 1969, p. 73-94.

21. Nielsen, R., 1997.

22. Piuz, A.-M., 1964; Revel, J., 1992.

During the first decades of the nineteenth century, the *pósitos* system suffered a sharp crisis due to war – Independence (1808-1814) and Carlist (1833-1840) – and fiscal extractions. Regardless of these calamities, most Spanish economic historians argue that the pósitos system underlined another problem: the *pósitos* did not serve their principal aim. The system's more brilliant years were the same years that featured the highest oscillations in wheat prices. It is true that Spain was not an exception in the stormy Europe of the Revolutionary and Napoleonic period. However, there are some reasons to believe that the *pósitos* slowed the wheat trade[23]. In another sense, José Bernardos believes that the *pósito* of Madrid, which was supported by the Royal Treasury, had a decreasing influence on the provisioning of the capital. In any case, it does not seem that they helped to stabilise markets and prices[24].

In the same way that the peak of the *pósito* system coincided with the crisis of subsistence, its decadence coincided with the stabilisation of prices. In 1850, the *pósitos* stored only two million hectolitres, perhaps a tenth of a normal national harvest. It is possible that they still played an important role in the rural credit of the south of Spain. However, during these years (or at any time), it does not seem that they had an influence on the construction of the national wheat market.

It was likely that merchants and grain wholesalers played a more relevant role than the *pósitos*. Their activities were not permitted until the publication of the *Código de Comercio* of 1829 and the *Real Decreto de Libertad de Comercio y Industria* of 1834. However, the first specific norm that authorised the storage and the commercial speculation on wheat – with important restrictions was the *Pragmatica de Libertad de Comercio* of 1765. Between those years, there were seven decades of forward and backward steps and, above all, uncertainty.

As we saw above, trade enlarges the size of a market. Thus, it reduced the oscillations in the prices because regional deficit and surpluses compensated each other. Market integration could be seen as a measure of the success of merchants in the exchange of goods. Studies regarding this topic note that eighteenth century cereal regional markets were partially integrated. However, at the end of the century and during the first decades of the nineteenth century, integration seemed to have deteriorated. It recovered in the middle of the 1820s, although the Carlist War disconnected

23. Castro, C., 1987; Escrivá, J. L. & Llopis, E., 1987, p. 122-123.

24. Bernardos, J. U., 2003, p. 170-198.

northern markets. Nevertheless, during the 1830s and 1840s, the Spanish wheat market seemed increasingly integrated. According to Barquín and other economic historians, before the construction of railways, the wheat markets were integrated[25]. In short, during the period of study, the size of the wheat market changed from that of a regional to that of a national field though slowly and with backward steps.

The end of the process of building a national wheat market was contemporary with the establishment of a protectionist policy[26]. In practice, the Tariff of *Trienio* (1820) banned the import of wheat and flour. Until this year, Barcelona and the other cities in the Mediterranean Sea obtained part of their wheat provisioning from Russia, Italy and Algiers. On the other hand, from 1814 onward, it was a strong agricultural expansion that made it possible to establish some discrete exports. In the period 1830-1855, Spain exported wheat and flour to Cuba and Europe. Likewise, grain moved between Spanish regions. For example, wheat from Aragón, Castile and La Mancha was transported to Barcelona through the ports of Tortosa, Santander, Valencia and Alicante. Even small quantities of wheat were traded from Oviedo and La Coruña to Barcelona. It is logical to suppose that during these decades, the conditions of the local markets reflected the conditions of the national market.

In short, we could suppose that eighteenth century prices reflect the conditions of production in the nearest provinces and that nineteenth century prices reflected the conditions of a national market. The effect of the seed factor could have been balanced by trade, especially during the nineteenth century. In other words, there is an important methodological implication. It is necessary to use different samples to estimate the volatility in production: for the eighteenth century, data from provinces close to each city; for the nineteenth century, data from « apparent » national consumption, or rather production plus commercial balance.

Final indirect estimates of elasticities of demand

Tables 5 and 6 show the estimates of the elasticities of demand drawn from two sets of sources: series of wheat prices for the period 1766-1808 and series of output during 1890-1914. I have used two methods to eliminate the trends: Ordinary Least Squares and Mobile Averages (five years).

25. Barquín, R., 2003, and Llopis, E., 2001.

26. The prohibition of wheat imports was suspended several times between the Decree of 1820 and the crisis of 1825-1826. Some of the permissions were conceded by local authorities, such as the Governor of Gerona.

Table 5. *Estimates of elasticity of demand*

1766-1808	*Provinces Output*	*OLS*	*MA*
Gerona	Gerona, Barcelona and Lérida	–1.25	–1.09
Barcelona	Barcelona and Lérida	–1.37	–1.32
Tolosa	Álava and Navarra	–0.69	–0.83
Valencia	Albacete and Valencia	–0.71	–0.80
Rioseco	Valladolid, Palencia and León	–0.60	–0.58
Pamplona	Navarra	–0.56	–0.82
Inland		–0.58	–0.70

Source. *Mercuriales* and GEHR (1991). See text,

Table 6. *Estimates of elasticity of demand*

1826-1854	*OLS*	*MA*
Segovia	–0.55	–0.59
Rioseco	–0.65	–0.74
Burgos	–0.64	–0.78
León	–0.77	–1.01
Tudela	–0.68	–0.72
Pamplona	–0.66	–0.77
Vitoria	–0.76	–0.88
Inland	–0.67	–0.79
Tolosa	–0.91	–1.09
Granada	–0.82	–0.80
Lorca	–0.84	–0.85
Medit.	–0.83	–0.83
Gerona	–1.41	–1.54
Santander*	–1.17	–1.18

* 1834-1854.

Source. *Mercuriales* and GEHR (1991).

In the eighteenth century, most of the elasticities reached « normal » values, ranging between –0.56 and –0.83. The more unusual results are the elasticities of Gerona and Barcelona. It does not seem credible that the curves of demand of wheat in Catalonia were elastic, but there is a very simple explanation: cereal imports were larger and improved supply, smoothing the oscillations in prices.

However, this explanation has a serious problem: in the next period, between 1826 and 1854, the elasticities of demand in Gerona and Santander were lower than –1.0. In those years, imports were banned, so it would be necessary to find other reasons. In the case of Gerona, it is possible to make the conjecture that the location of the city on the frontier between the Mediterranean and North regions, and close to the coast, provided a regular provisioning[27]. Santander was a door to the trade of flour and wheat to Catalonia, Cuba and, sometimes, England and France. These movements could be the cause of high but stable prices. In short, they are anomalous cases, and for this reason, they have been excluded by the estimate.

However, what can explain the value of Tolosa? The elasticity of demand in this city was very close to –1. Indeed, Tolosa was not a coastal city – it was 30 kilometres away from San Sebastian. It was not the door to wheat or flour export. It was not located in the cross junction of two consumption regions. Moreover, its surrounding region was a battleground during the Carlist War (1833-1839). In short, we only can suppose that wheat in Tolosa actually had a unitary curve of demand. In fact, in Guipúzcoa, bread made from wheat was a luxury good. Rich people ate bread made with wheat traded from Álava and Navarra (the *mercuriale* of Tolosa collects these grains separately). Poor people ate *borona*, a type of bread made from corn of the province. In the same way that wheat prices in Barcelona were higher and steadier than those in Castile, wheat prices in Tolosa were higher and steadier than those of corn, as shown in Table 7. If the standard deviation of the corn consumption series were similar to wheat, its elasticity of demand would range from –0.55 to –0.81. It would be similar to the wheat elasticity in Vitoria, a close and inland city.

Table 7. *Volatility of corn and wheat prices in Tolosa*

	Coefficient of variation		Standard deviation of detrended series	
	corn	wheat	corn	wheat
1766/1782	25.4	14.9	0.22	0.12
1788/1808	26.5	22. 1	0.24	0.20
1814/1826	43.9	35.8	0.23	0.13
1826/1854	23.6	20.3	0.18	0.13

Source. *Mercuriale* of Tolosa.

27. Indeed, R. Congost, 1989, p. 161, support that between 1768 and 1862 Gerona transformed from a cereal surplus province to a deficit one. Thus, the value of elasticity of demand in the eighteenth century could be more realistic.

Some of the samples – Gerona, Rioseco, Pamplona and Tolosa – cover both the eighteenth and nineteenth centuries. In all of these cases, the elasticities of demand in the first period are a bit higher than those in the second. This was probably due to a better exchange between regional surplus (inland) and deficits (coast). The rest of the estimates confirm the predictable results. In the north region, which featured many food alternatives and sea access, the demand for wheat had a price elasticity close to –1. The curve of demand in Inland Spain was relatively rigid. In the Mediterranean region, the values were halfway marks.

It is interesting to note that the estimates of the elasticity of demand in the eighteenth century in Rioseco were almost equal to those obtained by the « direct » procedure described in the section 4.2: –0.58/–0.60 and –0.56. Thus, it seems we are walking on solid ground.

Final estimates of all the elasticities

From now on, I will assume that the estimates of the elasticity obtained by detrended series with OLS are the best proxies for the « actual » values. As shown in the previous tables, these values normally represent most rigid curves of demand. By applying the condition of homogeneity to the two set of results (1766-1808 and 1826-1854), we obtain the following equations:

1^{st} period $0 = -0.91 + b_{2n} + b_{3n} = -0.70 + b_{2m} + b_{3mi} = -0.58 + b_{3mi}$ [6a]

2^{nd} period $0 = -0.91 + b_{2n} + b_{3n} = -0.83 + b_{2m} + b_{3mi} = -0.67 + b_{3mi}$ [6b]

Their solution then produces:

Table 8. *Spanish estimates of elasticities*

1766-1808 (six cities)	*North*	*Mediterranean*	*Inland*
Price elasticity of demand	– 0.71	– 0.69	– 0.58
Cross-price elasticity	> 0.11	0.11	–
Income elasticity	< 0.60	0.58	0.58
1826-1854 (eleven cities)	*North*	*Mediterranean*	*Inland*
Price elasticity of demand	– 0.91	– 0.83	– 0.67
Cross-price elasticity	> 0.16	0.16	–
Income elasticity	< 0.84	0.67	0.67

Source. *Mercuriales* and Gehr, 1991. See text.

*

A long historical tradition has explained the crisis of subsistence in Premodern Europe by supposing that the curve of demand in the wheat market was very rigid. The extreme dependence and sensitivity of consumers to changes in the food supply may explain the large oscillations in prices. The never-proven « Law » of King-Davenant provides theoretical support for this hypothesis.

On the other hand, another long economic tradition has marked the inability of agrarian economies to achieve sharp economic growth. They could not base their economic growth on wheat or other cereals because their income elasticities were too low.

In the nineteenth century, Spain, as other European countries, « jumped » into modernity. However, there is no evidence that agricultural systems were particularly successful. What is more interesting is that there is no evidence of large changes in the shape of the curves of demand. In fact, one of the most remarkable features of the elasticities of income, price and cross-prices is the stability. Basically, between the eighteenth and nineteenth century, income elasticities grew by 0.10/0.25, cross-price elasticities grew by less than 0.05, and price elasticities decreased by 0.10/0.20 and no more.

In Premodern Spain, the wheat curve of demand was rigid, but not extremely so. Indeed, it was not more rigid than the curves of other European countries. This conclusion is valid not only for coastal regions but for inland regions too, the most wheat-dependent part of Spain. In fact, in Castile, the elasticity of demand was –0.58, a value not very different from the values of coastal regions (between –0.69 and –0.91). Moreover, it was nearest to the value estimated for Europe as a whole (–0.65). Of course, prices oscillations in Spain were larger than those in across the rest of Europe. However, the oscillations in the production were also larger. The higher elasticity of demand in the coastal regions was a consequence of these regions' proximity to the sea, with a better supply and more nutritional alternatives. On the contrary, the fewer alternatives and the difficulties in gaining access to the sea explain the severity of crises of subsistence in Inland Spain between 1788 and 1812.

In any case, the crisis of subsistence was not a consequence of an extreme preference or need for wheat. Under normal conditions, people could afford a moderate increase in the price of bread. When harvests failed, they reduced their consumption or preferred other cereals, even barley. During those periods, the lack of alternatives to wheat in Castile may have seriously worsened the alimentary situation. Nevertheless, the essential parameters of wheat consumption were similar across the entire country.

Cross-price elasticities were one-quarter or one-fifth of the income elasticities This means that wheat substitutes did not play a relevant role in consumption. However, we cannot forget our initial assumptions. It is probable that a large increase in wheat prices would shift part of the consumption to the inferior cereals.

Finally, it could be interesting to observe the income elasticities. These values ranged from 0.58 to 0.84, which do not seem excessively low. Note that these elasticities were higher in the North and that they grew during the period of the study, probably as a consequence of the improvements in transportation and the increase in personal incomes. These estimates suggest neither a dynamic nor a stagnant market. Therefore nation's backwardness should be explained by reasons other than cereal agriculture development. However, of course, this would also depend on other factors.

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